DOCUMENT RESUME

ED 188 862 SE 030 873

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TITLE Using Clay as a Learning Resource for Teaching the History of Science.
PUB DATE 80
NOTE 26p.

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Ceramics; Grade 9; Resource Materials; *Science Activities; Science Course Improvement Projects; Science Education; *Science Equipment; Science Experiments; *Science History; Secondary Education; *Secondary School Science
IDENTIFIERS Introductory Physical Science

ABSTRACT

Construction of laboratory equipment from earthenware clay uses art as a way to incorporate the element of science history into an Introductory Physical Science (IPS) unit on distillation. Classroom techniques for working with clay to construct distilling apparatus are outlined. Other supplementary material from the arts, including slide presentations on original art work of past laboratories and sketches from primary sources, are also suggested. (CS)

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Using Clay as a Learning Resource for Teaching the History of Science.

I hear, and I forget
I see, and I remember
I do, and I understand.

Chinese proverb.

Joseph M. De Angelis

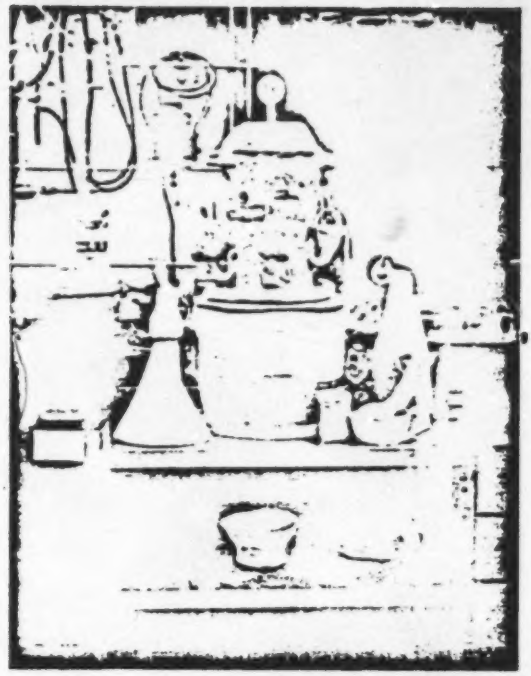
This work is adaptable for use by science teachers on any level for both terminal as well as college bound students and students in college.

Presented for completion of course requirements: Science Education 365. "Laboratory Experiments Relating to the History of Science." Temple University. Dr. Joseph S. Schmuckler and Dr. Eugene Udell. Fall, 1978-Spring, 1979, Department of Science Education.

SE 030 873

Top:

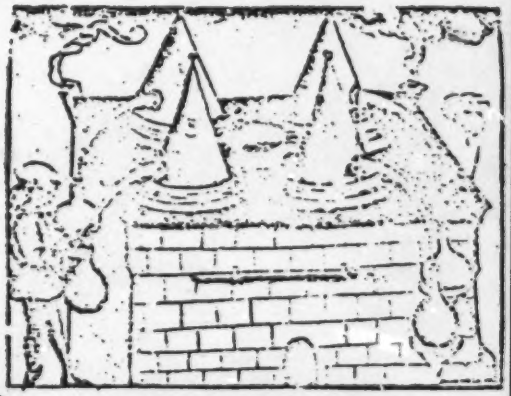
Fractionating Tower made in clay from sources listed below.



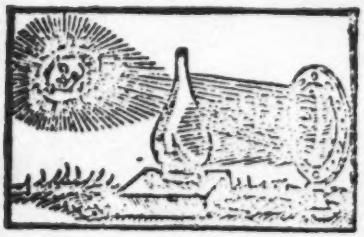
Teaching the History of Science

Using Clay as a Learning Resource.

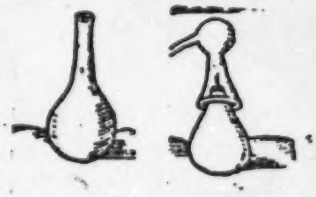
Serpens cooler, BIRINGUCCIO



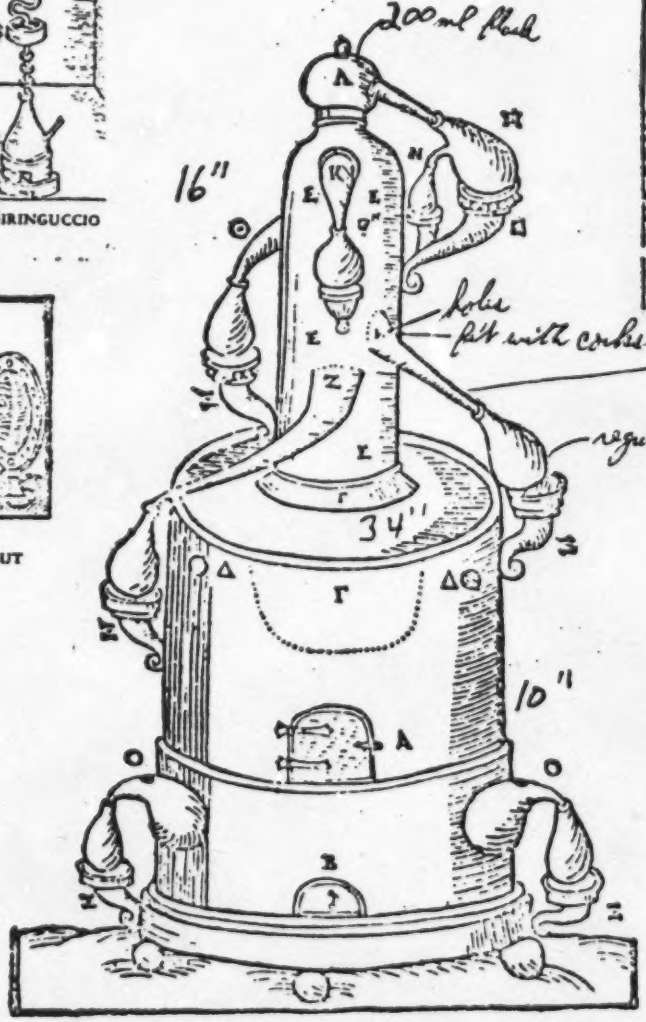
Water-bath with Rosenhut according to BRUNSCHWYGK



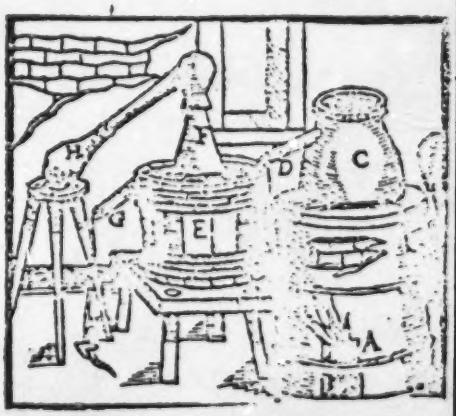
). Solis destillatio, LIÉBAUT



, GESNER



Fractionating tower, LIBAVIUS



Teaching the History of Science

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Abstract

Fundamentals of clay and ceramics, developed in the scientific past, are used by students in a laboratory to learn about the history of science. The primary objective is to have students reconstruct equipment from a distillation laboratory as studied in primary and secondary sources of the 1500's and 1600's, and art works of the period that portray "laboratories". In this way, students will experience the similarities in past design to the present. Teacher reference sections permit supplementing any existing science curriculum.

Using Clay as a Learning Resource for Teaching the History of Science.

Introduction

Most methods in the teaching of history involve the use of secondary or tertiary sources of information such as the interpretations read in most textbooks. The role of science in the development of history and the unique nature by which scientific information is discovered, is exempt from most standard history courses.

The outstanding feature in the history of science is the performance of the experiment. Most history courses do not include experimentation. Therefore, the history of science belongs in the science curriculum whose primary motivator is the experiment. As science educators we must begin to recognize this important distinction. A need exists for the designing of experiments from the history of science for use by science teachers on all levels.

Experiments relating to the history of science can provide meaningful learning experiences in the development of scientific thought in students. Furthermore, our ideas of science are based upon piecemeal linkages into the past. A science course that ignores its history, is at best an incomplete one. We cannot know where we are going if we

do not know where we have come from. Those who do not consider the history of science relevant, are "doomed to repeat it."

Method

Subjects. Students of any age can be given the opportunity to develop greater awareness, self-understanding, and appreciation into the scientific past by reconstructing experiments that are from the history of science. This unit of study focuses on a 9th grade physical science class, whose students are homogeneously grouped with respect to STS achievement batteries. Average to above average students were used in the piloting of this unit, however, the technique can be adapted to provide for the ability level of any group. Specifically, the prescribed curriculum of the school system was the (IPS) Physical Science (Reference Note 1). IPS is a laboratory oriented science program whose objective is to provide students with the basic tools for the identification of matter. The development of the atomic model for matter is also stressed, as well as the process by which scientific information is acquired. Unfortunately, much of the historical process involving the scientists who discovered the methods, have been eliminated.

Procedure. The chapter on Separation Techniques in the (IPS) curriculum, contains a modern laboratory approach to the study of distillation. Experience dictated that distillation is an extremely motivating area for most students. Many good questions always came from students on this unit. Perhaps the tremendous increase in teenage drinking, alcoholism, the influence of the drug culture, and the continuing energy crisis, ect. , all provide a springboard of curiosity and inquiry. Many students of this age and intellectual level appear to be most interested in the concrete operational factors that are a part of their universe of experience. Inotherwords, the historical, technological, and sociological influences of the distillation process are important to them.

With this assessment, concrete materials were needed to provide students the opportunity to experience the process of distillation from an historical perspective. A literary search through primary and secondary sources revealed the use of clay as a medium through which distillation apparatus was constructed. (Reference Note 2) Indeed, Brunschwig (1500), and others after, have written and illustrated numerous pieces of laboratory equipment for the scientist-craftsman to build for the science laboratory.

The primary objective in this unit is to have students reconstruct equipment from a distillation laboratory as dipicted in such primary sources as Brunschwig (1500), Libavius (1600), and other scientists of the time, as well as artists who helped preserve the early chemical laboratories through their paintings. All of this was to be compared to our so called modern equipment. In this way, it is hoped that the student will experience the similarities in past design to the ideas behind the equipment of today. Inotherwords, the ideas of distillation were based upon the scientific past.

Clay is a medium through which this historical experience can be re-lived through the centuries.

General Objectives

(1) To provide students the opportunity to research discover information on the history of distillation as it compares to their present study of the process (Reference Note 1).

(2) To allow students to express their creativity by experiencing art work illustrating the distillation laboratory, and. then, using clay, model and mold a piece of laboratory or distillation apparatus from the past.

(3) To generate an attitude of appreciation for

the past, as it relates to the history of distillation, by emphasizing similarities of past design to the ideas in the present.

Behavioral Objectives.

(1) Students will perform experiment 1.1: "The Distillation of wood." (IPS, Haber-Schaim, et al)

(2) Students will demonstrate a working knowledge of the distillation process as evidenced by achievement on an examination.

(3) Students will watch a slide presentation on art reproductions from the history of science as supplied by the Fischer Scientific Company and Temple University. (Reference Note 3).

(4) A library research assignment is to be written and submitted. The topic will be "The History of Distillation from Ancient Times to the Present."

(5) Students are to be prepared to present the assignment to the class.

(6) Each student is to design and mold a model of laboratory equipment from the past, using earthenware clay and hand techniques presented by the teacher.

(7) Students will prepare a final written assignment on "How This Equipment from the Past is Related to Our Present".

Working with Clay: Some Basic Fundamentals. The term ceramics embraces a wide variety of products and is applied in general to anything made from clay. The transformation of "earth" into pieces of "ware", both of a useful and aesthetic property, is the corner stone of science. Man taking the earth and working it, for improving the quality of life, is a fundamental goal that should be developed in all of science. Clay in the science classroom can therefore help students experience the cultural past to better appreciate the present.

Wares. Generally speaking, the ceramist classifies types of ware according to properties such as color, vitreousness (i. e. degree of porosity), translucency, and composition. Pottery, stoneware, porcelain, and china, are all made from clays. The composition of the clay and the degree to which it is heated in an oven called a kiln, determines the type of ware that is produced. (See Table 1)

The clay that is being suggested for use in the classroom is a water based synthetic clay. It is similar to the clay used in the making of flower pots. It is worked by hand, molded into an imagined shape, dried for about a week, and "fired" in a kiln oven to about 1900 degrees (F) for about four hours. (See Figure 5). The firing produces a chemical change in the composition of the clay. The

silica, water, and other minerals interact to produce the permanent "stone-like" property. (See Table 1 and Reference Note 4).

Distillation equipment from the past was constructed of such material because the normal boiling point temperatures of the chemicals that were being extracted and purified, were below the melting point temperatures of the clay. For this reason you can make a distillation set up from the past that actually functions with the use of an electric hotplate in place of charcoal. A functional chemical laboratory from the past can therefore be recreated in clay. Although the types of "furnaces" varied through time, the basic process of the transformation of clay into stone has been known since Biblical times, possibly even longer according to recent evidence. Clay is therefore a material rich in history and culture. Perhaps the first object ever made by man was molded from clay.

Electric fired kiln ovens are usually used for firing the pieces. Since kilns are expensive (around $500.), the classroom pieces can be taken to a neighborhood ceramic shop for firing. Your neighborhood University art department might also provide this service. The pieces need not be fired but rather shellacked or sprayed with laquer for support. However, the shrunken unfired clay is extremely

brittle. Firing provides students the opportunity of experiencing the transformation effect from clay to stone.

Coloring is not a necessity but can also provide a springboard into the history of art and colors and its relationship to science, chemistry in particular. Coloring or "glazing" as it is called, is usually accomplished by a variety of methods. Some color compounds are etched into the soft clay before firing, but the method used is related to the type of design or color finish that is desired. There are different types of glazes, each formulated with specific compounds for specific color combinations. Iron compounds can produce reds, copper compounds can produce blues, ect. The physical properties of the formulas for the glaze, are related to the color produced. The science of creating colors from substances in the earth and in extracting from plants, is an important dimension that may be explored with students. This unit provides for such an undertaking.

Although there are commercially mixed glazes, it is possible to mix your own glazes. The chemistry of the mixtures provide a unit rich in scientific inquiry. The actual glazing is accomplished by wiping, diping, or brushing on a mixture of the formulated glaze. The glaze also contains glass crystals. The glazed piece is refired

in the kiln for about another four hours. This causes the glass crystals to melt over the piece and for the color to take effect. This also helps to seal the piece. There are low fire glazes which melt at 1500° - 2000° F. , and higher fired ones. There are also lead free glazes for pieces that will be used for eating or drinking.

Perhaps you will want to consider at this point, the influence of art to science. The designer of a piece, for a scientific lab of the past or just as art, is involved in the formulation of glazes, composition of clays, firing process, ect. All are process in the history of science. This integrated attitude may also be developed with your students.

Techniques in the Classroom. Moist clay is more convenient for the classroom, although dry clay can be mixed with water. Unfired pieces can be broken up and reused. All clay needs to be "wedged" which is squeezing out all the air between the clay. This can be easily done by you and your students by constructing a wedging board (see Figure 2), or by using the palms of your hands to roll out the clay over and over, and turning the clay in on itself. This removes air bubbles from the clay. Trapped air bubbles expand in the firing process and can explode the piece.

The following represent some easy techniques that with little practice you can demonstrate to your students.

1) Pinch Pot. Roll the clay into a ball of a size that can be held in the palm of your hand. Press fingers into the ball, making a center depression. Slowly pinch the clay outward forming the walls of the "pot-like" piece of lab equipment visualized in your mind. Strive for a constant thickness of always not less than one-half an inch. Various sizes of flasks and fractionating columns can be made. (See Figure 3). A smooth finish can be obtained by wet hands and fingers.

2) Slab Process. First flatten clay with a rolling pin or about a twenty inch sawed off broom handle. Flat strips of wood on either side of the slab helps control even thickness. Cut slabs of clay with a knife. Pinch or score the edges of the slabs with "slip", made of clay mixed with water to obtain a pudding-like consistency. Join these slabs by a constant adding-on process to build rectangular shaped pieces. Seal the inside and outside corners with the slip, and let it dry to "leather hard" texture.

3) The Coil Process. (See Figure 4). Roll clay into a long rope or chain, and then coil it around and around to make a round bodied piece like a flask. Press the coils together to make a good join. Smooth with fingers. Texture

may be etched into the soft clay with any sharp tool. Let dry for a week to allow the water in the clay to escape.

4) A Wrap Around Process. Test tubes, beakers, flasks, fractionating columns, rubber tubing, ect. can all be fashioned into clay pieces that resembles those used in the 1500 science labs. Take wet paper towels and wrap around the object. Roll out one-half inch sheets of clay. Take clay sheets and mold around the towels on the object. Let dry about one day until clay is stiff but not brittle hard. Take knife and cut object in half. Join halves with slip and let dry. Some objects need not be cut in half, but pulled from the bottom, off the piece you are using for the mold. Of course, the bottom of the clay object must be left off and fashioned separately. It is rejoined to the piece with slip. A whole laboratory of equipment resembling artworks depicting Alchemy laboratories, can be re-created by this method. Any object can serve as a model to wrap the clay around. Illustrations from the past indicate that there is indeed a striking resemblance of the old clay equipment to modern glass equipment.

5) The Potters Wheel: Wheel Thrown. This is a machine operby foot or electrical power. A turntable spins with a designated torque and RPM, on which balls of clay are formed by hands into pieces of ware. They are considerably more refined and civilized looking than pieces formed by hand techniques without the aide of the mechanics. Potters wheels are expensive to buy, although some books have directions

for foot-operated models that can be constructed at home. They are not needed for this unit of study, but some students might be interested in learning more about clay and ceramics. Catalogues may be obtained for further information (see Reference Note 4).

6) The Firing Process. The length of time firing in the kiln is dependent upon the type of clay used (see Table 1). For this unit, clay was fired for about three hours to about 1900 degrees (F). Standard pyrometric cones are used in the kiln to help judge the firing process. The color of the firing clay is also an indication of its doneness. The cone simply melts at the set temperature, indicating that the process is over. Some kilns have a mechanical switch that is connected to the cone, that drops down and shuts off the kiln. The kiln is usually operated by electricity, but some older types use gas. Electricity is recognized as the superior and safer type of kiln, since it does not need to be vented (see Figure 5).

7) Vocabulary. In order to understand and talk intelligently about clay, the following vocabulary should be further developed with your students:

wares
kiln
wheel thrown
glaze
cones
grog
shrinkage
grog
wedging
slip
scoring
leather-hard
bisque
lead-free glaze
firing

8) Tools (see Figure I). Simple tools such as a ruler, a piece of wire, fishing line, pencil, paint brush, piece of cardboard, ect. are all that is needed. Wire or a knife can be used to cut the clay. The rest is up to the imagination of the designer. Ideas can be developed using the slide presentation alluded to earlier, and pictures from other primary reference sources (Reference Note 2).

Conclusion. Using earthenware clay, students can experience the historical process by designing, molding, and creating with their own hands, pieces of laboratory equipment. Many pieces actually can be functional, and students can perform experiments like the Alchemists and scientists of early times. Distillation was the process used to develop this unit, however other processes could be developed. Further supplementary material on clay techniques was provided, as well as slide presentations on original art works of past laboratories, and sketches from primary sources.

Similar units of study for students need to be developed on teaching the history of science, that enables students to experience by doing, the successes and failures of experiments relating to the history of science. It appears that this untapped resource in science education has been left dormant for too long. "I do, and I Understand."

Reference Notes

1. Haber-Schaim, et al. Introductory Physical Science (ed 2). Prentice-Hall, Inc. , Englewood cliffs, New Jersey. 1972.

2. "Brunschwygk to Boyle", Chapter Five of R. J. Forbes' Short History of the Art of Distillation. E. J. Brill, Leiden, Holland. 1948.

3. Slide presentation on "The History of Science". Reproductions of art works depicting science laboratories of the past. Not available to general public. Fischer Scientific Company, King of Prussia, Pa. Duplicate 35mm sets may be obtained through Dr. Joseph Schmuckler, Professor of Science Education, Temple Universi·y, Philadelphia, Pa.

4. Catalog of Potters Supplies. Arch T. Flower Company, Queen Street and Ivy Hill Road, Philadelphia, Pa. 19119. Phone: (215) 233-0653.

5. Katz, David, A. "The History of Alchemy and Early Chemistry." Unpublished Manuscript. Community College of Philadelphia, Department of Chemistry.

6. Schmuckler, Joseph, and Udell, Eugene. "Laboratory Experiments Related to the History of Science: Objectives". Course 365, Temple University, Department of Science Education. Philadelphia, Pa.

Bibliography on Working with Clay

Cottier-Angeli, Fiorella. Ceramics. Van Nostrand Reinhold Co. , N. Y. 1974.

Drake, Kenneth. Simple Pottery: How to Make Pottery Without a Wheel. Watson-Guptill Publications, N. Y. 1966.

Dungan, Julia, H. How to Make Pottery and Ceramic Sculpture. Doubleday and Co. , N. Y. 1960.

Evans, J. , and Marchant, H. Living Clay, A Potters Guide. Dai Nippon Printing Co, Hong Kong. Rigby Limited. 1969.

Farnworth, Warren. Beginning Pottery. Van Nostrand Reinhold Co. , N. Y. 1973.

Hofsted, Jolyon. Step-By-Step Ceramics. Golden Press, N. Y. 1967.

Horn, Jane. Ceramics: Techniques and Projects. Sunset Books, Lane Books Division, Menlo Park, Ca. 1976.

Hortung, Rolf. Exploring Clay, Hand Techniques. Van Nostrand Reinhold, N. Y. 1972.

Jolly, T. Introducing Handbuilt Pottery. Watson-Guptill Publications, N. Y. 1973.

Kenny, John, B. Complete Book of Pottery Making. Chilton Books, Philadelphia. 1963.

References for the History of Science

Asimov, Isaac. The Intelligent Man's Guide to the Physical Sciences. Washington Square Press, N. Y. 1968.

Bronowski, J. The Ascent of Man. Little, Brown and Co., Boston. 1973.

Brunschwygk, Hier. Liber de arte distillandi de simplicibus oder Buch der rechten Kunst zu Distillieren die eintzigen Dinge (Strassburg, 1500, Johann Gruninger). The Small Book of Distillation.

_____. Liber de arte distillandi de Compositis. The Big Book of Distillation. Strassburg. 1512.

_____. The vertuose Boke of Distyllacyon of the Waters of all maner of Herbes, with the fygures of the Syllatoryes. L Andrew, London 1527.

Crombie, A. C. Augustine to Galileo, The History of Science A. D. 400-1650. Falcon Educational Books, London. 1952.

Findlay, Alexander. Chemistry in the Service of Man. Longmans, Green and Co., London. 1919.

Forbes, Robert, J., Short Histroy of the Art of Distillation. Leiden, Holland. E. J. Brill. 1948.

Krel, E., and Lumb, E. C. (ed). Handbook of Laboratory Distillation. Elsevier Publishing Company, N. Y. 1963.

Kuhn, Thomas, S. The Structure of Scientific Revolutions. University of Chicago Press. 1970.

Landis, Walter, S. Your Servant the Molecule. The MacMillan Co. , 1944.

Lenard, Philipp. Great Men of Science. MacMillan Co. 1938.

Libavius, Andreas. Alchemia e dispersis passim optimorum auctorum... collecta. Francfort. 1597.

Liebuaun. "History of Distillation." Journal of Chemical Education 33; April 1956.

Mason, Stephen, F. A History of the Sciences. Collier Books, N. Y. 1962.

Plicher, Richard, B. , Butler-Jones, et al. What Industry Owes to Chemical Science. Authority of the Council of the Royal Institute of Chemistry. Chemical Publishing Co. , N. Y. 1946.

Wells, H, G, The Cutline of History, (Volumes I and II) Doubleday and Company, New York, 1961,

TABLE 1, TYPES OF CLAYS

MOIST CLAY MANUFACTURED BY STANDARD CERAMIC SUPPLY CO. Completely mixed-pugged and de-aired clay ready for immediate use. Clay is shipped in plastic bags. Two 25 lb. bags per carton. (Min. order 50# one type clay)

Price
All clays including assortment

50 lbs.	100 lbs.	500 lbs.	1000 lbs.	2000 lbs.
.18 per lb.	.17 per lb.	.15 per lb.	.14 per lb.	.125 per lb.

#101 BUFF CLAY — C/02-9

An all purpose stoneware clay with a wide firing range for throwing and modeling. Buff color at low temperatures and soft gray at cone 9.

	cone 4	cone 9
Shrinkage at	7.5%	9.0%
Absorption at	5.0%	3.8%

#103 RED CLAY — C/06-2

A low fire plastic terra cotta clay body designed for the classroom and studio. It has a warm earth color glazed or unglazed.

	cone 06	cone 2
Shrinkage at	7.0%	14.0%
Absorption at	12.0%	9.0%

#104 RED CLAY W/GROG — C/06-02

The controlled grog content of this low fire red clay helps reduce warping and shrinking and produces a textured surface without reducing elasticity. Good for large sculpture, slab or wheel.

	cone 06	cone 02
Shrinkage at	9.0%	11.5%
Absorption at	11.0%	8.5%

#105 WHITE CLAY — C/06-04

This plastic, low fire clay may be used for building, or throwing. Can be thinned for slip decoration.

	cone 06	cone 04
Shrinkage at	7.0%	7.5%
Absorption at	13.9%	13.0%

#119 CLAY — C/4-10

A clay for hand building techniques and especially fine for throwing. The addition of coarse silica sand gives this clay the required properties for extra large pieces. Natural earth colorants give pleasing orange-brown at cone 4 reduction fire.

	cone 4	cone 10
Shrinkage at	10.0%	13.0%
Absorption at	6.5%	6.0%

#130 PORCELAIN CLAY — C/7-9

An excellent white firing, high temperature, dense, plastic porcelain body with the wet strength throwing capabilities of high quality stoneware. Fires white in reduction or oxidation atmosphere.

	cone 7	cone 9
Shrinkage at	10.0%	10.5%
Absorption at	0.5%	0.25 to 0.0%

FIGURE 1

TOOLS FOR WORKING WITH CLAY

IN THE SCIENCE CLASSROOM

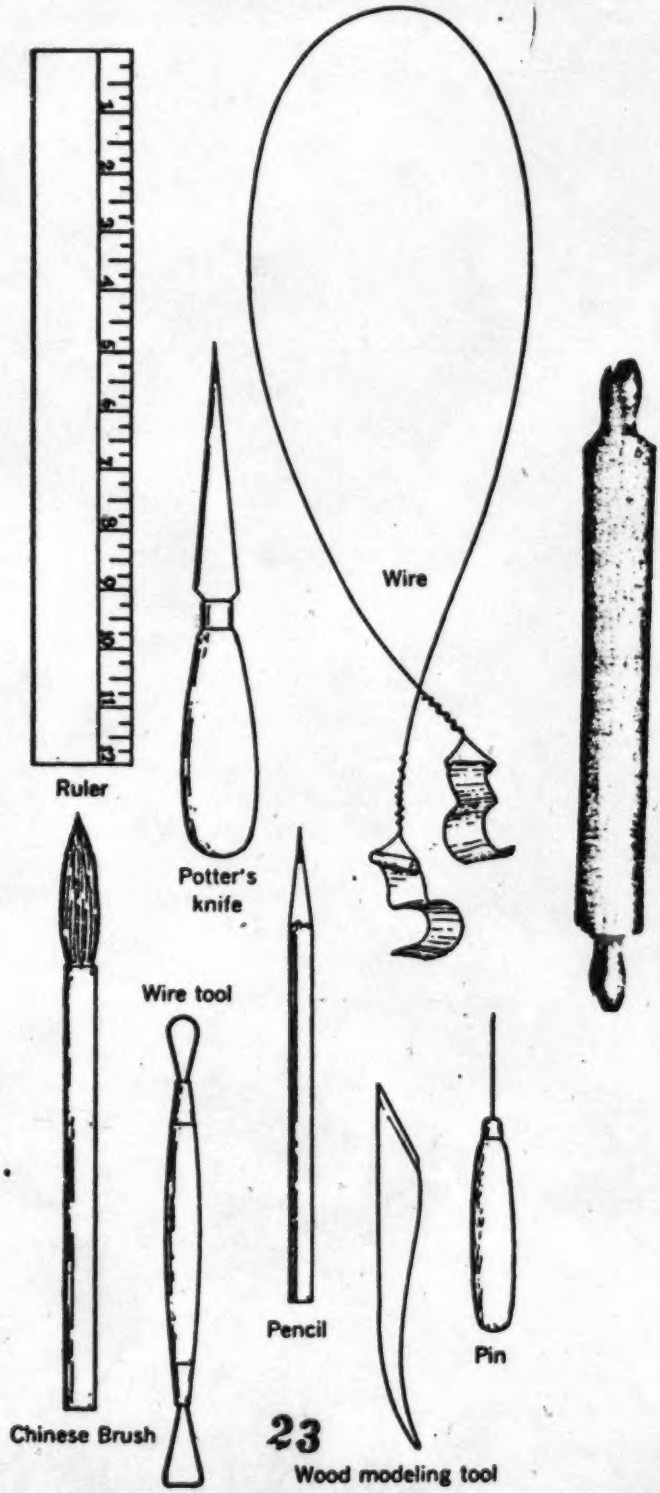

FIGURE 2, WEDGING BOX

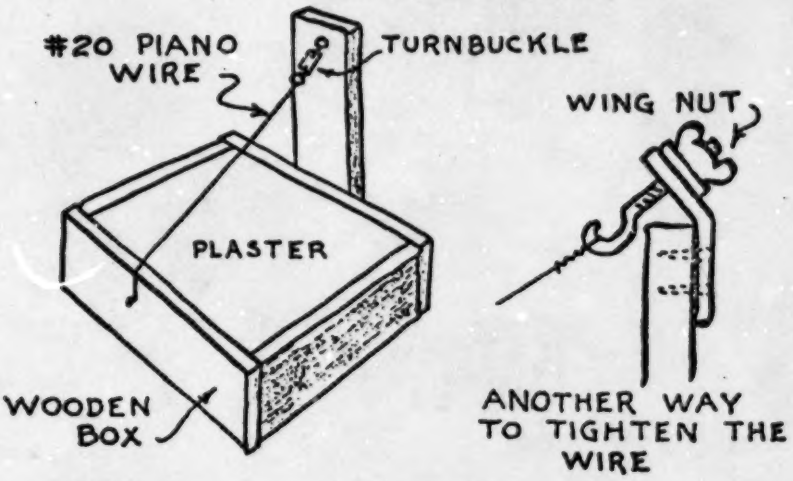

FIGURE 3, PINCH POT TECHNIQUE

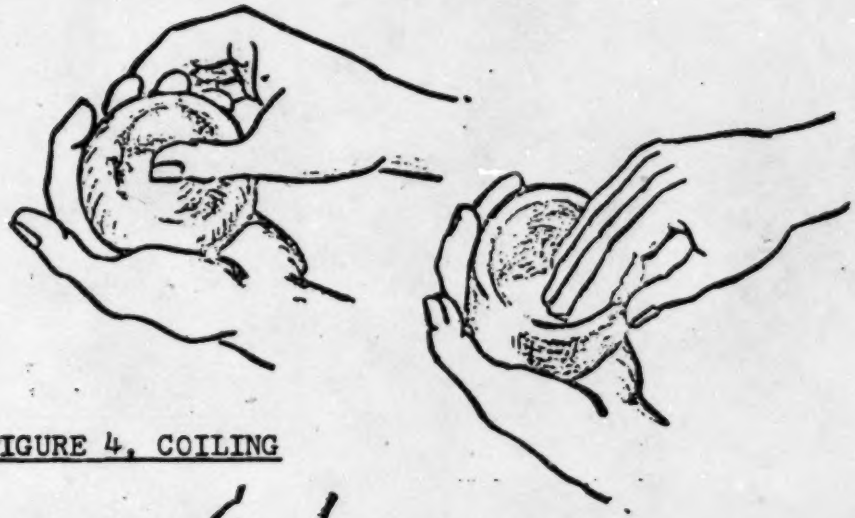

FIGURE 4, COILING

FIGURE 5, KILN

TABLE 2: TIME LINE CHART OF HISTORICAL EVENTS 100 YEARS BEFORE AND AFTER BRUNSCHWIG'S "KLEINES DISTILLIERBUCH" (LITTLE BOOK OF DISTILLATION),

1300-1400, Chinese Alchemy

1436-1437, Gutenberg's "Movable Type" Printing Press on which he issues the Mazarin Bible,

1452-1498, Savonarola imposed a rigidly Puritan regime on Florence,

1500's, "Kleines Distillierbuch" (Little Book of Distillation) (H, Brunschwig) Described the beginning of chemical processes and products to medicine,

1540's, Paracelsus attacked ancient medical authorities by showing the value of chemistry in the development of medicine, First Iatrochemist,

1503, Da Vinci painted the Mona Lisa,

1508-1512, Michelangelo painted the Sistine Chapel,

1509-1547, Henry VIII is King of England,

1513, Balboa reached the Pacific Ocean,

1515, Francis I became King of France,

1517, Luther posted the 95 theses,

1533, Reformation begins in England,

1534, Copernican theory of the Universe,

1564, Shakespeare is born,

1550, Campaign for and against chemistry in medicine,

1605, Francis Bacon's "The Advancement of Learning,"

1610, Galileo's studies with the telescope and microscope, and modern experimental mechanics,

(continued) TABLE 2: TIME LINE CHART OF HISTORICAL EVENTS,

1620, Francis Bacon's "Novum Organum", Mayflower Expedition,

1630, Rey's theory the air had weight and was taken up by metals on heating,

1632, Leeuwenhoek was born,

1628, Harvey's theory on blood circulation,
1638, Japan closed to Europeans (until 1865),
1648, van Helmont's On the Development of Medicine is published in which iatrochemistry is further developed,

van Helmont distinguishes between gases and the element air,

1660's, Royal Society of London is chartered by Charles II under the name of "The Royal Society for the Improvement of Natural Knowledge,"

Hooke names the cell,

Kepler founded modern experimental optics,

1686, Newton's Laws of Motion,

1690,,1700, The English school of chemistry declines and the German iatrochemical school is revived,